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From: Dominic Spaethling, Kenya Wheeler

Date: 4/4/06

Subject: Task 4E: Transit Oriented Development: Quantifying Density's Affect on Transit Ridership in the Bay Area (Final Version)

Over the last 25 years many studies have attempted to quantify the relationship between residential and employment density have on transit ridership. Although there are varying opinions as to the degree of influence there is consensus within the industry of a relationship between density and transit ridership. This memo will examines this relationship based on: 1) a summary of the existing research on the subject of transit ridership and its relationship to land use and 2) the development of a basic model for forecasting Bay Area transit ridership based on different land use scenarios.

Summary of Existing Research

Research on the topic of density and transit ridership can be divided into two basic categories: 1) observational research; studies that quantify the relationship between density and rail transit ridership and 2) transit ridership elasticity models; studies that develop ridership elasticities based on residential and employment density through statistical research.

Observational Research

Table 1 summarizes several studies that have attempted to quantify the relationship between density and transit ridership. As mentioned above all studies conclude that there is a relationship between residential and employment density and transit ridership.

Table 1

Summary of Research Connecting Residential and Employment Density to Transit Ridership

Author	Date	Reference	Research Finding
Pushkarev and Zupan	1977	Pushkarev, B. and J. Zupan, Public *Transportation and Land Use Policy*, Indiana University Press, 1977.	Suggests a minimum of 15 dwelling units per residential acre for frequent bus service and a minimum of 9 dwelling units per residential acre along a 25 to 100 square-mile corridor for light rail.
Cervero	1987	Cervero, R. *America's Suburban Centers – The Land Use Transportation Link*, Unwin Hyman, Boston, 1989	Determined that suburban employment centers with significant retail development exhibited a 3% increase in transit and rideshare use with every 10% increase in retail uses.
Cervero	1993	R. Cervero, *Ridership Impacts of Transit-Focused Development in California,* Federal Transit Administration, 1993.	• BART was used for 17.8% of home-based work trips originating within ½ mile of a BART station based on 1990 Census data • Based on survey data, in Sacramento 12% of residents within ½ mile of an LRT station used LRT and 3.2% used bus transit for their "main trip". At suburban employment sites in Sacramento that are within easy walking distance of LRT, 6.3% of workers arrived by rail and another 5.4% used bus transit.
Ross and Dunning	1997	Ross, C. and A. Dunning, *Land Use Transportation Interaction: An Examination of the 1995 NPTS Data*, 1997.	Based on data from the 1995 Nationwide Personal Transportation Study, transit trips as a percent of total trips varied by residential density: • 2.9 percent of all trips were taken on transit for densities between 250 and 1,000 persons per square mile • 3.0 percent of all trips were taken on transit for densities between 1,000 and 4,000 persons per square mile • 3.1 percent of all trips were taken on transit for densities between 4,000 and 10,000 persons per square mile • 11 percent of all trips were taken on transit for densities greater than 10,000 persons per square mile
Parsons Brinckerhoff	2002	Parsons Brinckerhoff, *Factors for Success in California's Transit-Oriented Development*. Sacramento: California Department of Transportation, Statewide Transit-Oriented	Reviews existing research on the subject of travel and transit usage and cites several statistical studies (including the TCRP H-1 Study addressed below) and their attempts to create elasticity based models for transit ridership. It also draws comparisons between transit oriented development and reduction of vehicle miles traveled (VMT).

<table>
<tr><td></td><td></td><td>Development Study.</td><td></td></tr>
<tr><td>Cervero and Duncan</td><td>2002</td><td>R. Cervero and R. Ewing, Travel and the Built Environment-Synthesis, University of California Institute of Urban and Regional Development, 2002.</td><td>Concludes that BART was used for 19.6% of home-based work trips originating within ½ mile of a BART station based on 2000 Census Data</td></tr>
<tr><td>Wilbur Smith Associates</td><td>2002</td><td>State Route 4 East Corridor Transit Study</td><td>• Found that TOD “offers the potential of 17,000 daily additional riders in the corridor.”</td></tr>
<tr><td>Fehr &Peers Associates</td><td>2003</td><td>tBART 580/680 Corridor Ridership Forecasting Methodology</td><td>• Found that TOD land use, built out to the greatest extent possible would result in ridership levels that are about 11% to 17% higher than ABAG baseline forecasts.</td></tr>
<tr><td>Lund, Cervero, Wilson</td><td>2004</td><td>Lund, Cervero, Wilson, Travel Characteristics of Transit-Oriented Development in California, Bay Area Rapid Transit District and California Department of Transportation, 2004.</td><td>• Determined that residents living near transit stations are around five times more likely to commute by transit as the average resident that works in the same city. This is the same ratio as found in Cervero’s 1993 California TOD study.
• Compared to workers in their surrounding region, TOD office workers are more than 3.5 times as likely to commute by transit, an increase for the 2.7 times ratio found in the 1993 study.
• Hotel patrons in TODs use rail transit more frequently for travel during their stay than travel to the hotel… (And) employees have high levels of rail transit use for their journey to work.</td></tr>
<tr><td>Cervero, et. al.</td><td>2004</td><td>TCRP Report 102, Transportation Research Board, 2004.</td><td>Based on an analysis of the three land use factors related to transit ridership (Density, Diversity, and Design), residential density within a one mile radius can increase potential rail transit ridership, as summarized below:
The Affects of Residential Density on Rail Ridership<table><tr><th>Density of Residential Units (Per Gross Acre)</th><th>Percentage of Rail Commuters</th></tr><tr><td>10</td><td>24.3%</td></tr><tr><td>20</td><td>43.4%</td></tr><tr><td>40</td><td>66.6%</td></tr></table>Residential rail transit ridership is also affected by employment density, where within a one mile radius of a rail station an increase in retail/service job density,</td></tr>
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			increases the likelihood of resident rail-commuting , as summarized below: The Affects of Retail/Service Job Density on Ridership

Density of Retail/Service Jobs (Per Gross Acre)	Percentage of Resident Rail Commuters
5	11%
20	26.5%
60	52.1%

Transit Ridership Elasticity Models

Given the body of research listed above, it is clear that residential and employment density along with other factors has a strong relationship to transit ridership. Two recent studies developed elasticity models to quantify the transit ridership benefits of Transit Oriented Development.

TCRP Project H-1 *Transit and Urban Form, Commuter and Light Rail Transit Corridors: The Land Use Connection, 1996 (H-1)*

This study conducted a statistical analysis of 19 existing light rail and commuter rail lines and their 261 stations to understand the relationship between a variety of land use related factors and their potential affects on transit ridership. The report concluded that residential density and CBD employment had a "highly positive" affect on both LRT and Commuter rail ridership. The elasticities associated with these results can be summarized as follows:

H-1 Residential and Employment Density and Ridership Elasticities

Indicator	Radius (Miles)	% Change in Population Density (persons per acre)	% Change in Ridership (elasticity)
Residential Population (LRT)	2	100%	50.7%
CBD Jobs and Job Density (LRT)	2	100%	33.8%
Residential Population (Commuter Rail)	2	100%	19%
CBD Job Density (Commuter Rail)	2	100%	64.1%

Source: Parsons Brinckerhoff et al, 1996

Given these relationships and elasticities an approximate change in ridership value can be calculated based on these factors. It is important to note that these elasticities are dependent on the presence of parking, feeder bus service and the station being a terminal station.

SACOG *Direct Light Rail Transit Ridership Models*, 2004

Sacramento County of Governments (SACOG) has also developed density based elasticity factors for determining light rail and bus ridership. Like the H-1 study, this study employed a regression analysis to develop elasticities for forecasting ridership. The elasticities associated with that study are summarized below:

SACOG Residential and Employment Density and Ridership Elasticities

Indicator	Radius (Miles)	% Change in Population	% Change in Ridership (elasticity)
Residential Population (LRT)	0.5	100%	30%
Employment (LRT)	0.25	100%	21%

Source: SACOG, 2004

These elasticities can be used for creating rough estimates of transit ridership based on increases in residential and employment density. Like the H-1 model these elasticities were developed assuming the presence of parking and feeder buses.

Next Steps: An Elasticity Model for the Bay Area TOD Study

Given the need for a simple but credible ridership model, PB will build on the elasticity research from the H-1 and SACOG studies. This study will use a combination of these two models to develop transit ridership numbers for the proposed TOD "Transit Planning Areas" (See Attachment A). There are two basic methodologies for this analysis.

One approach would be to use either the H-1 or SACOG elasticities and extend them across an entire rail transit or bus rapid transit corridor based on an appropriate catchment area (e.g. 1 mile on either side of corridor). Based on corridor ridership that MTC would provide, PB would create order of magnitude ridership numbers based on the residential (persons per acre) or employment (employees per acre) density increases in the catchment areas for the Baseline, Baseline '03, Smart Growth and Demand Technology forecasts.

A second approach would be to analyze each station individually based on the radii and transit ridership data provided by MTC. This would also require residential or

employment population data for each of the station areas for the appropriate radii. Corridor ridership would be calculated based on the aggregation of the individual station data. Transit ridership would be forecast for the Baseline, Baseline '03, Smart Growth and Technology Projections.

The next step is to review these proposed methodologies with MTC and to obtain appropriate transit ridership information for each "Regional Transit Planning Area" Corridor as shown in attachment A.

References

Cervero, R. *America's Suburban Centers – The Land Use Transportation Link*, Unwin Hyman, Boston, 1989

Cervero, R *Ridership Impacts of Transit-Focused Development in California,* Federal Transit Administration, 1993.

Cervero, R and Ewing, R., *Travel and the Built Environment-Synthesis,* University of California Institute of Urban and Regional Development, 2002.

Fehr & Peers Associates, *tBART 580/680 Corridor Ridership Forecasting Methodology*, Bay Area Rapid Transit District, Oakland, CA 2003

Lee, Richard W. Unpublished Memorandum to Gordon Garry, Mike McKeever (SACOG) Regarding: *SACOG Direct Light Rail Transit Ridership Models*, April 27, 2004.

Lund, Cervero, Wilson, *Travel Characteristics of Transit-Oriented Development in California,* Bay Area Rapid Transit District and California Department of Transportation, 2004.

Pushkarev, B. and J. Zupan, Public *Transportation and Land Use Policy*, Indiana University Press, 1977.

Parsons Brinckerhoff*, Factors for Success in California's Transit-Oriented Development*. Sacramento: California Department of Transportation, Statewide Transit-Oriented Development Study.2002

Parsons Brinckerhoff, Quade & Douglas, R. Cervero, Howard/Stein-Hudson Associates, J. Zupan, TCHRP H-1: Part 1, Transit Urban Form, *Commuter and Light Rail Transit Corridors: The Land Use Connection*, 1996.

Ross, C. and A. Dunning, *Land Use Transportation Interaction: An Examination of the 1995 NPTS Data*, 1997.

Wilbur Smith Associates, *State Route 4 East Corridor Transit Study*, Bay Area Rapid Transit District, Oakland, CA 2002